Occupational Safety Indicators for Forest Operations, Sawmilling and Wood-Based Panels Manufacture; an International Benchmarking

INDICADORES DE SEGURIDAD OCUPACIONAL PARA OPERACIONES FORESTALES, ASERRADEROS Y FABRICACIÓN DE TABLEROS EN BASE A MADERA; UNA EVALUACIÓN COMPARATIVA INTERNACIONAL

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ABSTRACT

Background: Given the lack of updated comparison to establish safety levels at where Chilean forestry and wood companies are facing with foreign competitors, a study of international statistical benchmarking was performed to find the rankings on occupational accidents and international excellence levels to achieve. **Method:** A survey was sent to 79 institutions and 96 contacts specialized in OHS from 37 countries to request data from years 2010 to 2012. The sample represented the workforce exposed to labor accidents that produces around 50% of roundwood and sawnwood, but 30% of wood-based panel globally. **Results:** The study reinforces that the most accurate, reliable and easy indicator to calculate, and also, to compare the accidentability, is fatal cases per million cubic meter harvested in the forest or processed in wood industries. Zero fatality was recorded only in some activities on forest operations (Belgium and Germany) and wood-based panels manufacture (Belgium, Finland, Italy, Lithuania and Sweden). Also, all countries improved their previous results on fatalities per 1 million m³ in the forest. **Conclusions:** Chile exhibits an intermediate international position for Fatality rate and Production v/s fatalities in forestry&logging, sawmilling and wood-based panels operations. There are no clear trends to build reliable rankings for Frequency rate, Severity rate, Production v/s nonfatal accidents and Production v/s lost time in wood processing.

Also, to make obvious the impact of labor accidents in forest and wood products, the study provides updated data and proposes to establish comparative indicators for the occupational accidents footprint between companies and/or countries.

Keywords: FREQUENCY RATE, SEVERITY RATE, FATALITY RATE, OCCUPATIONAL ACCIDENTS FOOTPRINT, OCCUPATIONAL HEALTH AND SAFETY, FORESTRY AND LOGGING, SAWMILLING, WOOD-BASED PANELS MANUFACTURE.

RESUMEN

Antecedentes: Ante la falta de datos actualizados para establecer niveles referenciales de seguridad laboral a los cuales las empresas forestales y madereras chilenas se enfrentan versus sus competidores extranjeros, se realizó un estudio estadístico internacional comparativo para definir rankings y establecer niveles de excelencia a lograr en accidentalidad ocupacional. **Método:** Se distribuyó una encuesta a 79 instituciones y 96 contactos especializados en SST de 37 países, solicitando datos del 2010 al 2012. La muestra representó a trabajadores expuestos a accidentes laborales que producen alrededor del 50% de la madera rolliza y aserrada y el 30% de paneles en base a madera del mundo. **Resultados:** El estudio reconfirma que el indicador más preciso, fiable y fácil de calcular, y también para comparar la accidentabilidad, es cantidad de casos fatales por millón m³ cosechados en el bosque o procesado en industrias madereras. Cero mortalidad se registró sólo en algunas operaciones forestales (Bélgica y Alemania) y fabricación de paneles de madera (Bélgica, Finlandia, Italia, Lituania y Suecia). Además, todos los países mejoraron sus resultados de trabajadores fallecidos por millón m³ en el bosque respecto a estudios previos. **Conclusiones:** Chile exhibe una posición internacional intermedia para tasas de Fatalidad y Producción v/s Casos Fatales en cosecha forestal, aserraderos y fabricación de paneles a base de madera. No hay tendencias claras para elaborar rankings fiables con tasas de Frecuencia, Gravedad, Producción v/s Accidentes no fatales y Producción v/s Tiempo perdido en procesamiento de la madera. Para evidenciar el impacto de los accidentes de trabajo en productos del bosque y elaborados de la madera, el estudio presenta datos actualizados y propone establecer indicadores comparativos para la huella de accidentalidad laboral entre empresas y/o países.

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Palabras clave: TASA DE FRECUENCIA, TASA DE GRAVEDAD, TASA DE FATALIDAD, HUELLA DE ACCIDENTALIDAD LABORAL, SALUD Y SEGURIDAD OCUPACIONAL, MANEJO Y COSECHA FORESTAL, ASE-RRÍO, FABRICACIÓN DE PANELES EN BASE A MADERA.

INTRODUCTION

At the convenience to provide a sound approach about the scopes, environments and reality where the research was developed, a brief state of the art related to production, employment, working conditions and occupational safety in forestry & logging, sawmills and wood-based panels operations is described below.

Production and employment

According to FAO¹, in 2012 near 1,656.70 million m³ were

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harvested in forests around the world, of which 39.13 million m³ were cut in Chile (2.4%; of which 38.42 million m³, or 98.1%, came from plantations). Regarding lumber, globally 412.73 million m³ were processed, with 7.16 million m³ produced in Chile (1.7%). As for wood-based panels, 301.12 million m³ were manufactured in the world; while Chile only provided 2.62 million m³ (0.9%).

In terms of workforce exposed to occupational accidents and professional diseases, also FAO² states that in 2006 the world had 3.876 million forestry workers, of whom 44,000 worked in Chile (1.1%); whereas in sawmilling and panels jointly worked 5.459 million people worldwide and about 27,000 in Chile (0.5%).

In Europe as a whole, 68% of the forest is privately owned and 27% public owned; 5% is owned by forest companies. Many countries have a high proportion of private forest, while others have a determinant proportion of public ownership.³

Working conditions and occupational accidents

Forestry and logging operations: As per Klun and Medved⁴, in spite of technological advances, forestry work continues to be one of the most dangerous activities, in particular when the workers do not have adequate training. Also, in most of the countries, forest work is characterized by its seasonality; e.g. 60% of Italian forest firms are not permanent.⁵

Regarding wages, forestry workers are generally below the average for other industries.⁶ In Finland, payment method for production carries a negative change in worker behavior⁷; while in Spain that most common type of remuneration is coinciding with high accident rates.⁸

The occupational safety and health (OSH) situation is most problematic among the self-employed, farmers and contractors in forestry and logging operations.⁹ The phenomenon of forestry contractors has since been spreading to practically all countries (almost all industrial timber harvesting in Chile has been done by contractors since the '80).¹⁰ Unfortunately, contracting has tended to result in deterioration on the quality of employment: a Swedish survey found that contractors work an average of more than 60 hours per week and 70% suffer from stress while 4 out 5 contractors are pessimistic as regards their future.¹⁰

Related to mechanization of logging operations, the degree of technological change varies from manual systems to totally mechanized ones. In the majority of European countries, working conditions have improved due to mechanization, but differs widely between nations. Some Central and Eastern Europe countries present high accident rates because of incomplete mechanization by low production and mountainous terrain.⁷

On the other hand, manual forest work traditionally exhibits riskier levels, e.g. in Louisiana (USA) and Sweden loggers have an accident rate 4 times higher than for machine operators.^{11,12}

According to Klun and Medved⁴, occupational fatalities decrease most obviously with the speed of introduction and share of logging & skidding machines, which is confirmed by the incorporation of that kind of mechanized equipment in Scandinavian countries.

Also on the perspective of fatalities, in USA forestry was 19 times higher with respect to other sectors and also 11.5 times greater than in the New Zealand forest sector, confirming that forest work is the most dangerous activity where loggers are the most exposed.^{11,13,14} A rate of fatal injuries of 100,000 workers per loggers was 129 in the year 1997 in USA and the national average fatality rate for all occupants was 4.7.¹⁵ Coincidentally, fatalities in

Germany were 3 times higher in the forestry sector than in construction, and twice as high as in agriculture.³ Personal communications provided by the Chilean Safety Association¹⁶ state that in forestry and logging operations during 2009 the fatality rate was at the level of 47.0 in Chile.

Klun and Medved⁴, in spite of the difficulties of comparison between countries, studied the evolution of fatal accidents from 1980 to 2004 in several European countries associated to round-wood production. An integration of their references, plus others from Cabeças³ in Spain, ACHS¹⁶ and Ackerknecht^{17,18} in Chile, are included in Table 1.

Table 1.

Comparison of fatal accidents in forestry & logging operations between Chile and some European countries.

Country	Fatal cases/million m ³ harvested	
	All Forest Operations	Small Scale Forest Operations
Finland	0.10	-
Sweden	0.11	0.80
Croatia	0.50	-
Spain	0.50	-
Germany	0.67	2.20
Chile	0.95	-
Austria	1.84	3.60
Switzerland	1.94	-
Slovenia	4.90	-

Source: Klun and Medved (4), Cabeças (3), ACHS (16), Ackerknecht (17,18) and Albizu-Urionabarrenetxea (7).

Sawmilling and wood-based panels manufacture: In many countries the wood products industry has a poor image. Noise, dust, injuries, exposure to chemicals and high labour turnover are still features of many woodworking enterprises. However, the recent modernization of sawmilling and wood processing plants has improved OHS conditions in the industry. The new technology has brought improvements in the physical environment in wood-working factories, and also, in terms of work organization, but with frequent reductions on employment.⁵

From the occupational safety point of view, some study had been conducted in wood products manufacturing in USA. In Maine, Holcroft and Punnett¹⁹ informed that injury rate for wood product manufacturing during 1987-2004 was almost twice the state-wide average for all jobs. The average accident rate for sawmilling in Chile was between 15 and 20%, one of the highest of all industries. The same was true in South Africa, where wood industries registered an accident frequency of 14%, the third highest in manufacturing industries.¹⁰

Regarding to fatalities in sawmills, Australia during 1982-1984 reported a high fatality rate (30) compared to the entire workforce in that country (8.1).²⁰ In Chile, personal communications held with the Chilean Safety Association¹⁶ reported that in sawmilling, during 2009, fatality rate for the same kind of wood processing was at the level of 13.9 in Chile.

Occupational accidents indicators

Nevertheless the availability of many safety indicators, such as accidents rate, frequency rate, injury rate, severity rate and others, is very difficult to find high levels of accuracy to compare occupational safety indicators between different OHS systems and countries.

According to Klun and Medved⁴, fatal accidents that occur at forest work are the most reliable data in the collected and

processed accident statistics and also good indicators of trends in development of forest work safety. Thence, the same authors stated that accident frequency should be expressed in the number of fatalities per 1 million m³ of gross removals.

Given the current lack of updated comparison, which allows to establish the safety level at where Chilean forestry and wood companies are facing with foreign competitors, a study of international statistical benchmarking was needed to find the rankings on occupational accidents and indicate the international excellence level which should be achieved in the future.

Importance of the study

It is pointed out that the mentioned above research it should be aimed to provide updated occupational safety statistics and references from different countries on behalf of various stakeholders related forest operations, sawmilling and wood-based panels manufacture.

Regarding the state of the art in this field, it can be stated that it is a difficult topic to address with high levels of accuracy, given the great diversity among countries and companies to measure OHS aspects, and also, in relation to standards and interpretations to analyze legal, medical and technical aspects on occupational accidents and diseases.

On the other hand, the implementation of the concept of occupational accidents footprint²¹ as a new preventive approach is proposed to the issue related to certify the chain of custody, creating more value for forest business. This involves applying indicators and explicit standards to sustainable forest management in order to mark accidents on products and services delivered, and also, to underpin the traceability of them (fatalities/million m³, total nonfatal accidents/million m³ and lost time/million m³). Consequently, the occupational accidents footprint in the forest sector is defined as a measure of the total amount of fatal cases at work, labor nonfatal accidents and their corresponding lost time associated to million cubic meters of production in forests, sawmilling or wood-based panels manufacture.

The methodology developed in the study is described below, and also results with their corresponding analysis, to finally deliver some conclusions.

METHODS

The technical information collected from countries on behalf of the research was requested based on the following antecedents:

Classification of economic activities (according to ISIC Rev.4 of United Nations 2008)²²: 0210 (Silviculture and other forestry activities); 0220 (Logging); 1610 (Sawmilling and planing of wood) and 1621 (Manufacture of veneer sheets and wood-based panels).

Occupational safety statistics data for each economic activity: Total nonfatal accidents for each year; Total fatal cases per year; Total lost time due to work accidents for each year; Average number of workers during the year; Total man hours of work performed in the year; Annual production for each economic activity (million cubic meters); Annual frequency rate (based at 1 000 000 hours worked men); Annual severity rate (based at 1 000 000 hours worked men) and Criteria used to define work accidents and their lost time for each country according to its OHS system.

Years: 2010, 2011 and 2012.

In fact, 79 specialized organizations (ILO, FAO, universities, OHS mutualities, ministries plus research & development institutes and companies) from 37 countries were consulted, representing a universe of technical information exchange with 96 directors, managers, academicians, researchers and technical staff in North America, Europe, Oceania and Latin America.

The information request was included in a form (available in Spanish and English), which was distributed via email to contacts being monitored their responses and consequent clarification of data, calculations and subsequent criteria by the same route with an average of 3 messages exchanged by participating specialist. In receiving answers, a marked tendency for countries was to maintain official accidents statistics only for Agriculture, Forestry and Fisheries as joint activity. Accordingly, any information about specific forest products, sawmilling and wood-based panels manufacture was investigated specifically by our contacts on behalf of the study.

Furthermore, given the great diversity of ways to register and calculate statistical information among countries (some nations begin accidents record from the day of occurrence of the accident itself; countries in the European Union included only accidents with more than 3 days lost time), it was necessary to implement allocation criteria for information standardizing and make it comparable to preventive realities among nations.

Thus, the main agreements were set arbitrarily and based on previous experiences as follows:

- Merge items 0210 and 0220 to obtain a single value for activities in the forest.
- Percentage of lost-time accidents: 1 day (7.5%), 2 days (22.5%) and 3 days (30.0%).
- Length of working days: 8 hours/day (40 hours/week; 50 weeks/year).

The data received were reviewed and then incorporated into the following formulas:

$$\text{Frequency Rate (FR)} = \frac{\text{Number of accidents} \times 1\,000\,000}{\text{Total man hours of work performed}}$$

$$\text{Severity Rate (SR)} = \frac{\text{Number of days lost by labor disability} \times 1\,000\,000}{\text{Total man hours of work performed}}$$

$$\text{Fatality Rate (FATR)} = \frac{\text{Number of fatal accidents at work} \times 100\,000}{\text{Total workers}}$$

Given the desirability of new, more direct and feasible indicators to compare different preventive realities in forest and wood industries operations between countries, as well as the convenience to mark an evidence of the impact of the accident on the products to favor the traceability processes in the chain of custody (occupational accidents footprint), the received data were also incorporated to calculate the following indicators of occupational safety associated with forestry & logging, sawmilling and wood-based panels manufacture production:

$$\text{Production vs Fatality (P/F)} = \frac{\text{Total fatal cases}}{\text{Million cubic meters produced}}$$

$$\text{Production vs Accidents (P/A)} = \frac{\text{Total nonfatal accidents}}{\text{Million cubic meters produced}}$$

$$\text{Production vs Lost Time (P/LT)} = \frac{\text{Total lost days from accidents}}{\text{Million cubic meters produced}}$$

The resulting information was ordered according to the above mentioned indicators (FR, SR, FATR, P/F, P/A and P/LT), separating different tables in the comparative results of countries with claims from one or more days lost and those who do from the day number 4. Any information that failed to be properly clear was discarded, leaving out data from some countries.

Finally, the information within the tables was ordered by hierarchy, establishing a ranking of performance among countries participating in the study.

RESULTS

Production and employment

According to FAO¹, during 2012 some 822.67 million m³ were harvested in the forests of the countries participating on the study (49.7% of world total). As for lumber, the research participant group provided 196.40 million m³ to the world (47.6%). Meanwhile, the wood-based panels industries of the analyzed sample contributed 91.89 million m³ (30.5%). Thence, the dataset appropriately represents to the global forest sector. In other words, dataset is equivalent to 3.9 times of roundwood, 4.0 times of sawnwood and 6.3 times of wood-based panels produced by EU-27 member countries in 2011 (calculation based on Eurostat information).²³ Regarding to forest ownership, most of the production came from privately own forests.

In terms of workforce exposed to occupational accidents and professional diseases on Earth, FAO² states that in 2006 about 537,000 forest workers labored in the studied countries (13.9%); while sawmilling and panels analyzed group employed 1,718,000 people (31.5%). Those workers belonged to countries from North America, Scandinavia, Central Europe, Eastern Europe, Oceania and South America, that provide different working conditions, levels of technology and development. Therefore, the sample represents adequately to a significant group of 18 nations with the most developed logging and wood processing operations.

Occupational accidents indicators

The surveys sent to 79 specialized organizations from 37 countries in North America, Europe, Oceania and Latin America had a response of 60.4% of managers, academicians, researchers and technical staff consulted (or, in other words, 48.8% of the surveyed institutions). The following tables present the results obtained on the study ordered by economic activity and occupational safety indicator, segregating as record start considering the lost time and the average values obtained from the years of the study.

FORESTRY AND LOGGING

Frequency rate (FR): Table 2 shows, that in terms of countries which consider accidents with 1 or more days of lost time, Canada is the leader (9.30), followed by Chile (1.7 times Canada) and USA (2.3x). For countries with 4 or more days lost, Sweden (0.85) and Czech Republic (1.2 times Sweden) are at the top of the ranking, and then, in far positions are United Kingdom (5.5x), Australia (8.5x), New Zealand (12.2x) and Finland (18.1x). At the end of the FR table for forestry & logging are Austria (47.9x), Belgium (53.6x) and Germany (69.0x).

Table 2.
Frequency rate for forest operations by country.

Country	Accidents with 1 or more days of lost time		Accidents with 4 or more days of lost time	
	Frequency rate (2010-2012 average)	Source (*)	Frequency rate (2010-2012 average)	Source (*)
Canada	9.30	FPAC	-	
Chile	15.40	ACHS	-	
USA	21.30	NIOSH/BLS	-	
Argentina	55.10	SRT	-	
Sweden	-		0.85	SWEA
Czech Republic	-		0.98	CSO
United Kingdom	-		4.70	NZFOA
Australia	-		7.25	NZFOA
New Zealand	-		12.95	NZFOA
Finland	-		15.40	TTL/TUT/FAI
Austria	-		40.75	AUVA
Belgium	-		45.60	FOA/EU-OSHA
Germany	-		58.65	BMAS

(*) Data elaborated by author using information provided by sources.

Severity rate (SR): Meanwhile, Table 3 displays Chile as the only country with 1 or more days of lost time to calculate SR (418.45). On the other hand, for countries where SR in forestry and logging takes in account 4 or more days lost, the best behavior is for Finland (253.90), followed by far by Austria (4.4x Finland) and Belgium (8.2x).

Table 3.
Severity rate for forest operations by country.

Country	Accidents with 1 or more days of lost time		Accidents with 4 or more days of lost time	
	Severity rate (2010-2012 average)	Source (*)	Severity rate (2010-2012 average)	Source (*)
Chile	418.45	ACHS	-	
Finland	-		253.90	TTL/TUT/FAI
Austria	-		1 131.05	AUVA
Belgium	-		2 079.35	FOA/EU-OSHA

(*) Data elaborated by author using information provided by sources.

Fatality rate (FATR): In regard to FATR in forestry & logging, Table 4 locates Germany and Belgium with zero fatality. Low fatality is shown in Australia (2.08) and Finland (4.49). Chile (19.15) is ranked 8th, immediately below of UK (16.67). Finally, with high FATR are placed Latvia (62.75), Spain (63.42), New Zealand (64.01), Austria (73.83), Canada (BC; 75.31) and USA (132.74).

Table 4.
Fatality rate for forest operations by country.

Country	Fatality rate (2010-2012 average)	Source (*)
Germany	0	BMAS
Belgium	0	FOA/EU-OSHA
Australia	2.08	NZFOA
Finland	4.49	TTL/TUT/FAI
Sweden	11.00	SWEA
Czech Republic	13.27	CSO
United Kingdom	16.67	NZFOA
Chile	19.15	ACHS
Poland	21.00	CILP/CLI
Argentina	29.32	SRT
Lithuania	40.61	EU-OSHA
Latvia	62.75	SLI/EU-OSHA
Spain	63.42	MEYSS
New Zealand	64.01	NZFOA
Austria	73.83	AUVA
Canada (Province of BC)	75.31	NZFOA
USA	132.74	NIOSH/BLS

(*) Data elaborated by author using information provided by sources.

Production v/s fatalities (P/F): Fatal cases/million m³: Germany and Belgium, because they have no fatalities in their forests, both exhibit a clean labor accidents footprint in volume of timber harvested between 2010 and 2012. Followers with accident footprints slightly marked are Finland (0.01), Australia (0.01) and Sweden (0.04). Chile (0.21) ranks No.10, at the same level on P/F than Czech Republic (0.21), surpassing the USA (0.22), UK (0.23), Poland (0.27), Austria (0.30), Latvia (0.34), Lithuania (0.47) and Italy (2.05) (Table 5).

Table 5.

Production v/s fatalities in forest operations by country.

Country	Fatal cases/million m ³ (2010–2012 average)	Source (*)
Germany	0	BMAS/FAO
Belgium	0	FOA/EU-OSHA/FAO
Finland	0.01	TTL/TUT/FAI
Australia	0.01	NZFOA
Sweden	0.04	SWEA/FAO
New Zealand	0.16	NZFOA
Canada (Province of BC)	0.17	NZFOA
Spain	0.18	MEYSS/FAO
Czech Republic	0.21	CSO/FAO
Chile	0.21	ACHS/INFOR
USA	0.22	NIOSH/BLS/FAO
United Kingdom	0.23	NZFOA
Poland	0.27	CILP/CLI/FAO
Austria	0.30	AUVA/FAO
Latvia	0.34	EU-OSHA/FAO/SLI
Lithuania	0.47	EU-OSHA/FAO
Italy	2.05	INAIL/FAO

(*) Data elaborated by author using information provided by sources.

Production v/s accidents (P/A): Total nonfatal accidents with days lost/million m³: USA (6.48) and Poland (1.8 times USA) has the lowest impact on labor accidents footprint (according to number of nonfatal accidents with 1 or more days lost/million m³ harvested in forests). Chile (5.2x) is at the third position. While comparing P/A in countries with 4 or more days lost/millions m³ harvested in the forests, Sweden (1.48) leads the group; later are Lithuania (2.3x Sweden), New Zealand (4.6x), Belgium (5.7x), Finland (5.9x) and Australia (6.2x). At the bottom, are UK (8.8x), Austria (14.1x) and Czech Republic (16.8x)(Table 6).

Table 6.

Production v/s nonfatal accidents in forest operations by country.

Country	Accidents with 1 or more days of lost time		Accidents with 4 or more days of lost time	
	Total accidents/million m ³ (2010–2012 average)	Source (*)	Total accidents/million m ³ (2010–2012 average)	Source (*)
USA	6.48	NIOSH/BLS/FAO	-	
Poland	11.94	CILP/CLI/FAO	-	
Chile	33.50	ACHS/INFOR	-	
Sweden	-		1.48	SWEA/FAO
Lithuania	-		3.36	EU-OSHA/FAO
New Zealand	-		6.83	NZFOA
Belgium	-		8.44	FOA/EU-OSHA/FAO
Finland	-		8.73	TTL/TUT/FAI
Australia	-		9.22	NZFOA
United Kingdom	-		13.08	NZFOA
Austria	-		20.81	AUVA/FAO
Czech Republic	-		24.92	CSO/SLI/FAO

(*) Data elaborated by author using information provided by sources.

Production v/s lost time (P/LT): Total days lost/million m³: Besides Poland (610.08), which is in the 1st place, Chile is the other country that reported lost time on accidents in the woods with 1 or more days of absence at work (1.5 times Poland). For countries which count lost time since the 4th day, Finland (143.10) has the lowest footprint for days lost because of labor accidents per million m³ harvested in forests. Followers are Belgium (2.8 times Finland) and Austria (5.4x). The P/LT ranking ends with Czech Republic (11.1x)(Table 7).

Table 7.

Production v/s lost time in forest operations by country.

Country	Accidents with 1 or more days of lost time		Accidents with 4 or more days of lost time	
	Total days lost/million m ³ (2010–2012 average)	Source (*)	Total days lost/million m ³ (2010–2012 average)	Source (*)
Poland	610.08	CILP/CLI/FAO	-	
Chile	909.02	ACHS/INFOR	-	
Finland	-		143.10	TTL/TUT/FAI
Belgium	-		395.18	FOA/EU-OSHA/FAO
Austria	-		770.96	AUVA/FAO
Czech Republic	-		1 591.59	CSO/FAO

(*) Data elaborated by author using information provided by sources.

SAWMILLING

Frequency rate (FR): In Table 8 it shows that, in terms of countries which consider accidents in the lumber industry with 1 or more days of lost time, Canada leads (17.10), and then, are coming USA (1.9x Canada), Chile (2.2x) and Argentina (2.5x). In countries with 4 or more days lost, Sweden is at the top position for FR in sawmills (9.35), followed by Italy (1.2 times Sweden), Austria (2.9x) and Spain (4.8x). Behind, are Germany (6.4x), Belgium (7.0x) and Finland (7.1x).

Table 8.

Frequency rate for sawmilling by country.

Country	Accidents with 1 or more days of lost time		Accidents with 4 or more days of lost time	
	Frequency rate (2010–2012 average)	Source (*)	Frequency rate (2010–2012 average)	Source (*)
Canada	17.10	FPAC	-	
USA	32.25	NIOSH/BLS	-	
Chile	37.15	ACHS	-	
Argentina	42.05	SRT	-	
Sweden	-		9.35	SWEA
Italy	-		11.05	INAIL
Austria	-		27.30	AUVA
Spain	-		45.10	MEYSS
Germany	-		60.25	BMAS
Belgium	-		65.20	FOA/EU-OSHA
Finland	-		66.20	TTL/TUT/FAI

(*) Data elaborated by author using information provided by sources.

Table 9.

Severity rate for sawmilling by country.

Country	Accidents with 1 or more days of lost time		Accidents with 4 or more days of lost time	
	Severity rate (2010–2012 average)	Source (*)	Severity rate (2010–2012 average)	Source (*)
Chile	777.45	ACHS	-	
Austria	-		560.95	AUVA
Finland	-		1 000.65	TTL/TUT/FAI
Belgium	-		1 311.55	FOA/EU-OSHA
Spain	-		1 624.00	MEYSS

(*) Data elaborated by author using information provided by sources.

Severity rate (SR): On the other hand, Table 9 presents Chile as the only country reporting with 1 or more days of lost time to calculate SR in sawmilling (777.45). For countries where SR takes in account 4 or more days lost, Austria is at the first position (560.95), and later is Finland (1.8x Austria) followed by Belgium (2.3x) and Spain (2.9x). **Fatality rate (FATR):** As FATR in lumber production, Table 10 ranks Finland as best results (3.70), followed by Austria (2.3 times Finland), Germany (2.8x), Italy (3.9x), Chile (4.0x; 5th place), Spain (4.2x), Sweden (4.4x), USA (5.3x) and Lithuania (6.6x).

Table 10.

Fatality rate for sawmilling by country.

Country	Fatality rate (2010-2012 average)	Source (*)
Finland	3.70	TTL/TUT/FAI
Austria	8.50	AUVA
Germany	10.47	BMAS/FAO
Italy	14.38	INAIL
Chile	14.89	ACHS
Spain	15.72	MEYSS
Sweden	16.36	SWEA
USA	19.80	NIOSH/BLS
Lithuania	24.36	EU-OSHA

(*) Data elaborated by author using information provided by sources.

Production v/s fatalities (P/F): Fatal cases/million m³: Finland, having low fatality in sawmilling, exhibits a cleaner workplace accidents footprint in lumber volume processed during the 2010-2012 period (0.04). Followers, in terms of a more marked labor accidents footprint, are Austria (2.5 times Finland), Germany (2.8x), Sweden (3.0x), Chile (3.5x; 5th location in P/F), USA (7.2x), Belgium (18.2x), Spain (23.8x) and Lithuania (39.5x)(Table 11).

Table 11.

Production v/s fatalities in sawmilling by country.

Country	Fatality cases/million m ³ (2010-2012 average)	Source (*)
Finland	0.04	TTL/TUT/FAI
Austria	0.10	AUVA/FAO
Germany	0.11	BMAS/FAO
Sweden	0.12	SWEA/FAO
Chile	0.14	ACHS/INFOR
USA	0.29	NIOSH/BLS/FAO
Belgium	0.73	FOA/EU-OSHA/FAO
Spain	0.95	MEYSS/FAO
Lithuania	1.58	EU-OSHA/FAO

(*) Data elaborated by author using information provided by sources.

Production v/s accidents (P/A): Total nonfatal accidents with days lost/million m³: Canada leads with the least impact on labor accidents footprint (9.26), in terms of number of nonfatal accidents with 1 or more days lost /million m³ processed in sawmills, followed very far by Chile (P/A 7.4 times Canada) and USA (9.7x). Sweden has the cleanest labor accidents footprint in sawmilling while lost time is counted since the 4th day (13.62), followed by Lithuania (2.2x Sweden) and Austria (4.3x). Quite behind are Belgium (7.6x), Finland (9.3x) and Germany (10.1x)(Table 12).

Production v/s lost time (P/LT): Total days lost/million m³: Chile was the only country that reported lost time on accidents in sawmills with 1 or more days of absence at work for P/LT (1,442.52). In countries where lost time count starts at the 4th day, Austria has the lowest labor accident footprint due to total days lost/million m³ of lumber (1,425.28). Continued by Finland (1.3 times Austria), and then, Belgium (2.2x)(Table 13).

Table 12.

Production v/s nonfatal accidents in sawmilling by country.

Country	Accidents with 1 or more days of lost time		Accidents with 4 or more days of lost time	
	Total accidents/million m ³ (2010-2012 average)	Source (*)	Total accidents/million m ³ (2010-2012 average)	Source (*)
Canada	9.26	FPAC	-	
Chile	68.93	ACHS/INFOR	-	
USA	89.67	BLS/NIOSH/FAO	-	
Sweden	-		13.62	SWEA/FAO
Lithuania	-		30.54	EU-OSHA/FAO
Austria	-		58.16	AUVA/FAO
Belgium	-		102.83	FOA/EU-OSHA/FAO
Finland	-		126.32	TTL/TUT/FAI
Germany	-		137.53	BMAS/FAO

(*) Data elaborated by author using information provided by sources.

Table 13.

Production v/s lost time in sawmilling by country.

Country	Accidents with 1 or more days of lost time		Accidents with 4 or more days of lost time	
	Total days lost/million m ³ (2010-2012 average)	Source (*)	Total days lost/million m ³ (2010-2012 average)	Source (*)
Chile	1 442.52	ACHS/INFOR	-	
Austria	-		1 425.28	AUVA/FAO
Finland	-		1 895.95	TTL/TUT/FAI
Belgium	-		3 080.48	FOA/EU-OSHA/FAO

(*) Data elaborated by author using information provided by sources.

WOOD-BASED PANELS MANUFACTURE

Frequency rate (FR): Table 14 presents Canada at the top of the FR ranking in wood-based panels production for countries which consider accidents with 1 or more days of lost time (14.85), closely followed by Chile (1.1 times Canada), and later, USA (1.5x). In countries with 4 or more days lost, Sweden is the leader for FR in wood-based panels (8.70). Then follow Austria (2.5x Sweden), Italy (2.7x) and Finland (2.8x). At the end of the group are Germany (4.6x) and Belgium (5.1x).

Table 14.

Frequency rate for wood-based panels manufacture by country.

Country	Accidents with 1 or more days of lost time		Accidents with 4 or more days of lost time	
	Frequency rate (2010-2012 average)	Source (*)	Frequency rate (2010-2012 average)	Source (*)
Canada	14.85	FPAC	-	
Chile	16.85	ACHS	-	
USA	22.70	NIOSH/BLS	-	
Sweden	-		8.70	SWEA
Austria	-		21.75	AUVA
Italy	-		23.60	INAIL
Finland	-		24.15	TTL/TUT/FAI
Germany	-		40.20	BMAS
Belgium	-		44.25	FOA/EU-OSHA

(*) Data elaborated by author using information provided by sources.

Severity rate (SR): In turn, Table 15 shows just Chile reporting with 1 or more days of lost time to calculate SR in panels manufacture (410.85). In relation to countries taking in account 4 or more of days lost, Finland is leader in SR for the wood-based panels industry (202.80), followed by Austria (1.7x Finland's) and Belgium (2.8x).

Fatality rate (FATR): Regarding FATR in wood-based panels production, Table 16 shows to Finland, Sweden, Belgium, Italy and

Table 15.
Severity rate for wood-based panels manufacture by country.

Country	Accidents with 1 or more days of lost time		Accidents with 4 or more days of lost time	
	Severity rate (2010-2012 average)	Source (*)	Severity rate (2010-2012 average)	Source (*)
Chile	410.85	ACHS	-	
Finland	-		202.80	TTL/TUT/FAI
Austria	-		347.30	AUVA
Belgium	-		560.95	FOA/EU-OSHA

(*) Data elaborated by author using information provided by sources.

Table 16.
Fatality rate for wood-based panels manufacture by country.

Country	Fatality rate (2010-2012 average)	Source (*)
Finland	0	TTL/TUT/FAI
Sweden	0	SWEA
Belgium	0	FOA/EU-OSHA
Italy	0	INAIL
Lithuania	0	EU-OSHA
Germany	2.94	BMAS
Chile	3.98	ACHS
USA	7.11	NIOSH/BLS
Austria	8.39	AUVA

(*) Data elaborated by author using information provided by sources.

Lithuania with zero fatality; in other words, a null impact on labor accidents footprint. The ranking continues with Germany (2.94), Chile (3.98; 7th place), USA (7.11) and Austria (8.39).

Production v/s fatalities (P/F): Fatal cases/million m³: Because of zero fatality in panels manufacture, Finland, Sweden, Belgium, Italy and Lithuania show no trace of occupational accidents on volume of wood-based panels produced in the 2010-2012 period. Countries negatively marked in the work accidents footprint are Germany (0.02), USA (0.14) and Austria (0.15). The P/F ranking is closed by Chile with an extremely high footprint mark on occupational accidents on wood-based panels manufacture (11.55)(Table 17).

Table 17.
Production v/s fatalities in wood-based panels manufacture by country.

Country	Fatal cases/million m ³ (2010-2012 average)	Source (*)
Finland	0	TTL/TUT/FAI
Sweden	0	SWEA/FAO
Belgium	0	FOA/EU-OSHA/FAO
Italy	0	INAIL/FAO
Lithuania	0	EU-OSHA/FAO
Germany	0.02	BMAS/FAO
USA	0.14	NIOSH/BLS/FAO
Austria	0.15	AUVA/FAO
Chile	11.55	ACHS/INFOR

(*) Data elaborated by author using information provided by sources.

Production v/s accidents (P/A): Total nonfatal accidents with days lost/million m³: Regarding number of nonfatal accidents with 1 or more days lost/million m³ processed in panel manufacture, Canada is leading in terms of the least impact on labor accidents footprint (71.70), followed by USA (1.3 times Canada) and Chile (1.4x; 3rd place). Lithuania has the cleanest labor accidents footprint in the wood-based panels industry, in terms of P/A while lost time is counted since the 4th day (3.81), followed very far by Sweden (8.0x Lithuania) and Austria (11.2x). At the end of the group are Belgium (20.8x), Germany (21.1x), Italy (25.2x) and Finland (40.1x)(Table 18).

Table 18.
Production v/s nonfatal accidents in wood-based panels manufacture by country.

Country	Accidents with 1 or more days of lost time		Accidents with 4 or more days of lost time	
	Total accidents/million m ³ (2010-2012 average)	Source (*)	Total accidents/million m ³ (2010-2012 average)	Source (*)
Canada	71.70	FPAC	-	
USA	90.38	BLS/NIOSH/FAO	-	
Chile	97.82	ACHS/INFOR	-	
Lithuania	-		3.81	EU-OSHA/FAO
Sweden	-		30.37	SWEA/FAO
Austria	-		42.87	AUVA/FAO
Belgium	-		79.07	FOA/EU-OSHA/FAO
Germany	-		80.38	BMAS/FAO
Italy	-		95.98	INAIL/FAO
Finland	-		152.63	TTL/TUT/FAI

(*) Data elaborated by author using information provided by sources.

Production v/s time lost (P/LT): Total lost days/million m³: In the case of production of wood-based panels, Chile was the only country that reported lost time on accidents with 1 or more days of absence at work for P/LT (2,386.11), showing a high impact on labor accidents footprint. For countries where lost time count starts at the 4th day, Austria shows the footprint with lower labor accidents for days lost per million m³ manufactured (901.81), followed by Belgium (1.6x Austria) and Finland (2.1x)(Table 19).

Table 19.
Production v/s lost time in wood-based panels manufacture by country.

Country	Accidents with 1 or more days of lost time		Accidents with 4 or more days of lost time	
	Total days lost/million m ³ (2010-2012 average)	Source (*)	Total days lost/million m ³ (2010-2012 average)	Source (*)
Chile	2 386.11	ACHS/INFOR	-	
Austria	-		901.81	AUVA/FAO
Belgium	-		1 410.00	FOA/EU-OSHA/FAO
Finland	-		1 871.92	TTL/TUT/FAI

(*) Data elaborated by author using information provided by sources.

DISCUSSION

Production and employment

Regarding to Chile (and based on FAO data for 2012), its annual roundwood production (39.134 million m³) is slightly lower than Finland (44.614 million m³) and Germany (42.863 million m³) logging levels, and a little higher with respect to Poland (32.001 million m³), but over New Zealand (25.970 million m³) and Austria (12.831 million m³). These production levels are not comparable with North American countries (USA, 320.729 million m³; Canada, 151.151 million m³).

The Chilean workforce in the woods (44,000 workers) is the same of that employed in Germany (44,000 persons), below than Poland (49,000 people) and above with respect to Finland (23,000 workers), Austria (7,000 persons) and New Zealand (7,000 workers). In terms of its productivity (and using also FAO data to calculate), Chile (889.41 m³/worker) is located in between of Germany (974.16 m³/worker) and the UK (798.91 m³/worker), but far below from Finland (1,939.74 m³/worker), which is almost a fully mechanized logging country (compared to other countries that have a significant percentage of manual work in the woods), Austria (1,833.00 m³/worker), a main user of logging towers similar to Chile, and New

Zealand (3,710.00 m³/worker), country that shares with Chile the same type of Radiata pine plantations, and also, both are near in logging technology and workforce outsourcing level.

Also taking in account FAO information of 2012, annual sawnwood production in Chile (7.160 million m³), and under very similar level of technology in sawmilling, its output is lower than Austria (8.952 million m³), higher than Finland (4.357 million m³) and New Zealand (3.840 million m³), but extremely far from Germany (21.031 million m³) and Sweden (15.900 million m³). Again, these levels of lumber production are out of comparison with North America (USA, 66.435 million m³; Canada, 40.715 million m³).

FAO data for wood-based panels in 2012 state that Chile produced 2.619 million m³ in high technology industrial plants, very similar to Spain (2.699 million m³), above than New Zealand (1.963 million m³), Finland (1.272 million m³) and Sweden (0.754 million m³), but extremely below than Germany (12.148 million m³), Canada (11.126 million m³) and Poland (8.486 million m³). USA produced 32.495 million m³ that year.

The same source only provides general workforce data for wood processing as joint information. In terms of productivity, the calculation made with FAO data states 362.18 m³/workers per year for Chilean in wood industries, the same yearly amount than New Zealand (362.29 m³/worker), closed to Austria (338.22 m³/worker), but below than Sweden (438.26 m³/worker) and Canada (405.01 m³/worker).

Occupational accidents indicators

Despite that is difficult to make comparisons between countries, since definitions and occupational safety systems differ widely from one country to another, study results allow us to provide some overall interpretations.

Forestry and logging:

Since previous data for number of fatal cases in the woods in relation to 1 million m³ is available, it is possible to prove evident changes in accidentability for forestry and logging operations. All of the countries on the study with former data improved their Production v/s Fatalities indicators, but only Germany and Belgium reached zero labor accidents footprint in the bush. Chile shows 0.21 for 2010-2012, while in 2007 had 0.95.

Again, Scandinavian countries show excellent results (Finland, 0.01; Sweden: 0.04), which can be explained by favorable terrain conditions for mechanization, highly developed logging systems also associated to effective safety programs and adequate entrepreneurial organization with forest proprietors. From the new research, Oceanic countries appears between the best positions (Australia, 0.01; and New Zealand, 0.16); while Eastern European countries, due mainly to organizational changes and lower mechanization, are located at the second part of the ranking (Czech Republic, 0.21; Poland, 0.27; Latvia, 0.34 and Lithuania, 0.47). North American countries are in the middle (Canada, BC, 0.17 and USA, 0.22); while the rest of Central Europe countries have variable records (Spain, improved from previous 0.50 to 0.18); UK, 0.23; Austria, 0.30 and Italy, 2.05).

Regarding Fatality rate in USA forestry, compared to same operations in New Zealand (and formerly reported by some authors), the study found out that the relation of 11.5 times greater in America lowered down to 2.1. Also, in USA, the comparison with other research of 1997 (129) shows and slight deterioration regarding the present study (132.74).

In relation to Frequency rate and Severity rate in forestry and logging operations, there are not clear trends to explain differences between countries or group of them (independent of when lost time starts its count). Also, previous researches where to find data to compare were not available. The same lack of tendencies was found on results for the proposed indicators to measure the occupational accidents footprint (Production v/s nonfatal accidents and Production v/s lost time).

Sawmilling and wood-based panels manufacture

Due to the lack of previous published researches on occupational accidents indicators related to wood processing, it is no possible to set a clear point-to-point analysis in order to delivery some sound conclusions for these activities.

Nevertheless, the study states that in sawmilling operations all countries reported fatalities, but in wood-based panels manufacture Nordic countries (Finland and Sweden) reported zero fatal cases, and thence, a null impact on occupational accidents footprint resulted for those specific productions.

Related to Chile, a Fatality rate of 13.90 reported by the ACHS¹⁶ for sawmills in 2009 had a slight increase in 2010-2012 up to 14.89. Same source also released information for a zero fatality in wood-based panels manufacture in 2009, but that unfortunately changed into a Fatality rate of 3.98 during 2010-2012. Finally, the accident rate in Chilean sawmills of 15-20% announced by ILO in 2001 lowered down to 6.72% in 2012 (mainly explained by substantial improvements on technology, besides new strong attitudes and compromises towards safety at all company levels).

Also lack of trends was found on results for all indicators in sawmilling (Frequency rate, Severity rate, Fatality rate, Production v/s fatalities, Production v/s nonfatal accidents and Production v/s lost time), with the exception of Austria (on his lost time category), which always used to be ranked between the top three countries, followed sometimes by Sweden, Finland or Germany.

For wood-based panels, Austria, Sweden and Finland experienced variable behaviors. Chile is quite behind in the ranking with great challenges to improve his indicators and competitiveness. Again, another opportunity for further researches and contributions to create improved data banks in order to favor better analysis.

CONCLUSIONS

- Chile exhibits an intermediate international position in terms of Fatality rate and Production v/s fatalities in forestry and logging operations; and ranks the same level for sawmilling and wood-based panels manufacture.
- For better comparisons, and with the aim of to find real Chile position and its competitiveness on safety, it is important to increase significantly data from countries that count lost time on forest operations and wood industries since the same day of the work accident.
- There are no clear trends between countries, or group of them, in order to build a reliable ranking for Frequency rate, Severity rate, Production v/s nonfatal accidents and Production v/s lost time in sawnwood and wood-based-panels operations.
- The research reinforces the previous finding that the most accurate, reliable and easy indicator to calculate, and also, to compare the accidentability, is fatal cases per million cubic meter harvested in the forest or processed in wood industries (sawnwood or wood-based panels).

- All countries from former studies on fatalities per 1 million m³ in the forest lowered their numbers, with best results in Nordic countries, mainly explained by their highly developed mechanized harvesting systems with excellent occupational safety and health programs plus adequate entrepreneurial organization with forest proprietors. Zero fatality was recorded only in some activities on forest operations (Belgium and Germany) and wood-based panels manufacture (Belgium, Finland, Italy, Lithuania and Sweden).
- With relation to the desirability of transparency in forest and wood products, and specifically to carry with itself the impact of occupational accidents in their aggregated value, it is proposed to establish indicators for the occupational accidents footprint associated to production: fatal cases/million m³, total nonfatal accidents/million m³ and lost time/million m³.
- The study provides a new scenario for discussion and benchmarking on occupational safety indicators in the forest sector, and also promotes further comparative studies and motivates the implementation of broader data banks (it is an excellent opportunity for ILO to implement methodologies that allow more reliable statistical comparisons on OHS between countries). But one of the most interesting edges offered by the study is arguing about the implementation of the occupational accidents footprint to mark products and services in forestry operations and wood processing.
- There are marked trends in countries and international organizations to keep official statistics only at level of Agriculture, Forestry and Fisheries as a joint activity. Accordingly, any information about specific forest operation, sawmilling or wood-based panels manufacture should be investigated especially upon request.
- Classifications of activities vary between countries (not necessarily follow UN ISIC), forcing to study alleged equivalences, and therefore, also impose assumptions and estimates that deduct technical and scientific validity to results.

ABBREVIATIONS

ACHS:	Asociación Chilena de Seguridad/Chilean Safety Association.
AUVA:	Allgemeine Unfallversicherungsanstalt/General Accident Insurance Company.
BHS:	Berufsgenossenschaft Holz und Metall/Professional Association of Wood and Metal.
BLS:	Bureau of Labor Statistics, U.S. Department of Labor.
BMAS:	Bundesministerium für Arbeit und Soziales/Federal Ministry of Labour and Social Affairs.
CILP:	Central Institute for Labour Protection-National Research Institute
CLI:	Chief Labour Inspectorate
COLMENA:	Colmena Vida y Riesgos Profesionales/Colmena Life and Risk Prevention.
CORMA:	Corporación Chilena de la Madera/Chilean Timber Corporation.
CSO:	Czech Statistical Office

EU-OSHA:	European Agency for Work and Health at Work.
FAI:	Federation of Accident Insurance Institutions.
FAO:	Food and Agriculture Organization.
FISO:	Fundación Iberoamericana de Seguridad y Salud Ocupacional/ Ibero-American Foundation of Occupational Safety and Health.
FITEC:	Forest Training and Education Council.
FOA:	Fund for Occupational Accidents.
FPAC:	Forest Products Association of Canada.
HSE:	Health and Safety Executive.
ILO:	International Labor Organization.
INAIL:	Istituto Nazionale per L'Assicurazione contro gli Infortuni di Lavoro/National Institute for Work Accidents Insurance.
INFOR:	Instituto Forestal/Forest Institute.
KWF:	Kuratorium für Waldarbeit und Forsttechnik/Board of Forestry and Forest Technology.
MEYSS:	Ministerio de Empleo y Seguridad Social/Ministry of Employment and Social Security.
MU:	Massey University.
NIOSH:	U.S. National Institute of Occupational Safety and Health.
NZFOA:	New Zealand Forest Owners Association.
SKOGFORSK:	Forestry Research Institute of Sweden.
SLI:	State Labour Inspectorate
SRT:	Superintendencia de Riesgos del Trabajo/ Superintendency of Occupational Risks.
SWEA:	Swedish Work Environment Authority.
TTL:	Työterveyslaitos/Finnish Institute of Occupational Health.
TUT:	Tampere University of Technology.
UCHILE:	Universidad de Chile/University of Chile
WSN:	Workplace Safety North.

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